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**Quality Characterisation of biscuits from blends of Bambara groundnut (*Vigna subterranea*), Ground bean seed (*Macrotyloma*) and Moringa seed (*Moringa oleifera*) flour**

**Abstract**

The nutrient composition and the acceptability of biscuit from composite flours of wheat Bambara groundnut (*Vigna subterranea*), Ground bean seed (*Macrotyloma*) and Moringa seed (*Moringa oleifera*) were evaluated. Bambara groundnut (*Vigna subterranea*), Ground bean seed (*Macrotyloma*) and Moringa seed (*Moringa oleifera*) was dried, processed into flour and used to substitute wheat flour as composite flour. The composite flour was at 0, 10, 20 and 30% level of the flour blends, the resulting mixtures were then used to produce biscuits. The pasting properties, proximate composition, minerals, physical (spread ratio, weight, thickness and colour) and sensory properties of the composite biscuit were evaluated. The pasting properties of the flours showed that pasting temperature were 68.50 °C - 70.0 °C and the peak viscosity range from 101.17 RVU – 207.17 RVU, while Break down (43.0 RVU) was highest in 90% wheat: 10% (Bambara- groundnut-ground bean- moringa flour) (WFF<sub>1</sub>). The protein content increased from 12.50% in the control (100% wheat flour) to a range of 14.40% - 16.19% in the biscuits; crude fibre decreased from 2.83 to 2.40 - 1.84%.; ash content increased from 1.26% to a range of 1.53 - 2.01%, while carbohydrate and energy value reduced from 69.20 to 65.54 - 63.36% and 384.04 to 391.34 - 391.55% respectively. As the ratio of blends level increased, the thickness, diameter and weight increased but the spread ratio decreased. There was a significant difference in the overall acceptability of the control (100% wheat flour) and 10% blends substitution samples.

25 Keywords: Biscuit; Bambara groundnut; moringa; wheat; pasting.

## 26 1. INTRODUCTION

27 Protein-energy malnutrition (PEM) remains a major public health problem in Africa and some  
28 part of the world. A survey showed that high levels of malnutrition exist in children under 5  
29 years of age with 46.9% stunted, 31% under-weighted and 11.6% [1], with a view to finding  
30 alternative and cheaper sources of protein to solve the problem of malnutrition due to inadequate  
31 protein in nutrition which is a prevalent problem in developing world, especially in Nigeria.  
32 Legumes are recognized as a major source of dietary protein and energy. Dietary importance of  
33 legumes has been well established [2 - 5]. Due to their high protein content, legumes have been  
34 promoted as a source of protein especially for low-income families in countries with high rates  
35 of protein-energy malnutrition and the usage of animal protein is an economic constraint. They  
36 are also excellent sources of carbohydrate, fairly good sources of minerals and vitamins [6].  
37 Legumes also contain numerous health protecting bioactive phytochemicals such as phenolic  
38 acids, flavonoids, isoflavones, saponins, phytosterols and sphingolipids [7]. *Macrotyloma*  
39 *geocarpa* Harm is a legume and an indigenous crop cultivated in parts of West Africa for food [8  
40 - 9]. Ground bean can be consumed alone or supplemented with foods from other groups [10].  
41 The proximate and antinutritional properties of fermented *Macrotyloma geocarpum* H. seed flour  
42 were reported [11 - 12] while its chemical, functional and amino acid composition were also  
43 reported [8-13]. *Vigna subterranea* (L). Verdc. commonly called Bambara groundnut is known  
44 as 'epa roro' in Yoruba, okpa in Igbo. In Côte d'Ivoire, it is commonly called 'Clô-Nglô' among  
45 the Akan Tribe [14]. Reports has it that Bambara groundnut flour has been used in making bread  
46 in Zambia [15] and milk [16 - 17]. Previous works have been reported on the nutritional and  
47 functional properties of protein concentrate and isolate from *Vigna subterranea* (L).Verdc.

48 effect of domestic processing methods on chemical composition, anti-nutritional factors, *in-vitro*  
49 protein and starch digestibility on Bambara groundnut seed flour [18 - 19]. *Moringa oleifera* tree  
50 is a miracle tree due to its rich source of micro and macro nutrients [20]. Inclusion of *Moringa*  
51 *oleifera* seed as a food fortificant in producing snacks from bambara groundnut and ground bean  
52 is essential [21]. Biscuits are consumed all over the world as snack food by children and adults  
53 It is a form of confectionery product dried to a low moisture content [22]. Biscuits had been  
54 suggested as a better form of composite food than bread because of its ready to eat nature. These  
55 characteristics make protein-rich biscuits attractive in countries where protein energy  
56 malnutrition is prevalent [23] and also in areas needing child feeding programmes. Biscuits with  
57 high sensory ratings had been produced from blends of wheat/cowpea flour Okaka and Isieh  
58 [24], wheat/soybean McWatters *et al.*, [25], wheat and full fat soya [26 - 28] and composite flour  
59 from wheat and plantain [29]. Health conscious people are moving away from consumption of  
60 refined baked products to the consumption of functional, natural and fibre rich products  
61 Therefore, this research on the incorporation of flour blends of Bambara groundnut (*Vigna*  
62 *subterranea*), Ground bean seed (*Macrotyloma*) and Moringa seed (*Moringa oleifera*) as a  
63 supplement in biscuit formulation was conducted with the focus to establish an alternative means  
64 of utilization of the blends through investigation of its quality characteristics.

## 65 **2. MATERIALS AND METHODS**

### 66 **2.1 Sources of Materials**

67 Ground bean (Accession Tkg-8) and bambara groundnut (Accession TVSu-506) were procured  
68 from the International Institute of Tropical Agriculture (IITA), Ibadan, Oyo State. Moringa seed  
69 was purchased from Afe Babalola University Ado Ekiti (ABUAD) farm Ado Ekiti, Ekiti State.

70 **2.2 Preparation of Ground bean, Bambara groundnut and moringa seed flour.**

71 Ground bean (*Macrotyloma*), Bambara groundnut (*Vigna subterranea*) and Moringa seed  
72 (*Moringa oleifera*) were sorted manually and washed under running water, oven dried at 60 °C  
73 for 20 h. All samples were milled using laboratory blender and sieved using a 200 µm mesh  
74 sieve (British Standard) to obtain fine flour of seeds powder. The flour were packed separately in  
75 plastic container, sealed and stored at room temperature (~27 °C) until required for use.

76 **2.3 Formulation of flour blends**

77 The four different blends of wheat, ground bean, bambara groundnut and moringa seed flour  
78 (Table 1) are used in composite flour. The composite flour were stored in airtight container until  
79 required.

80 **Table 1: Blend formulation for biscuit**

Formulations	Wheat flour (%)	Composite flour (%)
WFF <sub>0</sub>	100	0
WFF <sub>1</sub>	90	10
WFF <sub>2</sub>	80	20
WFF <sub>3</sub>	70	30

81

82 **2.4 Production of wheat-bambara -ground bean-moringa biscuits**

83 The biscuits were produced using the method described by Uchenna and Omolayo [30], with  
84 slight modifications. The flour were mixed together manually for 5 min. to get a creamy dough  
85 The baking powder (2.5 g) and vanilla (5 g) were then added. The measured amount of water

86 (125 ml) was gradually added using continuous mixing until good textured, slightly firm dough  
87 was obtained. The dough was kneaded on a clean flat surface for four min. It was manually  
88 rolled into sheets and cut into shapes using the stamp cutting method. The cut dough pieces were  
89 transferred into fluid fat greased pans and baked in an oven at 105 °C for 20 min., cooled and  
90 packaged for further analysis.

#### 91 **2.5 Pasting Properties of Bambara groundnut, ground bean seed and their blends.**

92 The pasting properties of the flour blends were evaluated by using a Rapid Visco Analyser  
93 (RVA) (Perten Instruments RVA 4500). The moisture content of the samples were determined  
94 and used to calculate the weight of sample and water required to prepare the suspensions with the  
95 aid of the sample calculator on the software of the RVA. The sample and water was weighed into  
96 the canister and the paddle was fitted into it. The canister was placed on the tower of the RVA. It  
97 was a programmed heating and cooling cycle. Parameters recorded were pasting temperature  
98 (PT), peak viscosity (PV), minimum viscosity (MV), or trough viscosity (TV), final viscosity  
99 (FV), and peak time (PT). Breakdown viscosity (BV) was calculated as the difference between  
100 PV minus MV, while total setback viscosity (SV) was determined as the FV minus MV. All  
101 determinations were performed in triplicate and expressed in rapid viscosity units (RVU)  
102 (Newport Scientific Australia, 1998).

#### 103 **2.6 Physical analysis of biscuits**

104 The diameter (width), thickness and spread factor were determined according to AACC [31].

#### 105 **2.7 Proximate Composition**

106 The proximate composition (moisture, protein, fats, ash, fibre and carbohydrate) were  
107 determined as described by AOAC [32] method.

## 108 **2.8 Colour Determination of wheat-bambara-ground bean-moringa biscuits**

109 The colour of the samples was measured using the ColorTec – PCM<sup>TM</sup> (USA US Patent 5,137,  
110 64 Foreign Patent Pending Accuracy Microsensors Inc Pitsford, New York). The L, a, b type of  
111 scales was used. Values for L (0-100, black to white), a (positive-negative, red to green) and b  
112 (positive-negative, yellow to blue), were determined. An important factor characterizing the  
113 variation of colour in the test sample is the total colour difference or TCD. The total colour  
114 difference  $\Delta E$  was defined by the Minolta equation [33].

$$115 \quad \Delta E = [(\Delta L)^2 + (\Delta a)^2 + (\Delta b)^2]^{1/2} \quad (2.1)$$

## 116 **2.9 Determination of minerals wheat-bambara-ground bean-moringa bread and** 117 **biscuits:**

118 Mineral Analysis. Potassium, sodium, calcium, magnesium, manganese, phosphorus, copper,  
119 zinc, and iron in the samples were determined by X-ray spectrometric method (XRS). The mini  
120 pal 4 version PW4030X-ray Spectrometer (PerkinElmer, Inc., USA) was used to determine the  
121 concentration of the elements in the samples. The mini pal version PW4030 X-ray Spectrometer  
122 is an energy dispersive microprocessor controlled analytical instrument designed for the  
123 detection and measurement of elements in a sample (solids, powders, and liquids), from sodium  
124 to uranium [34].

## 125 **2.10 Evaluation of Sensory Attributes of Bambara groundnut, moringa and Ground** 126 **bean biscuits**

127 All sensory analyses were conducted in a sensory laboratory with adequate lighting and no odor  
128 environment. Panelists were selected based on familiarity with control samples, recognition and  
129 perception of common odors. The biscuit samples were prepared and presented to 30 untrained  
130 panelists coded with random three digits. Water at room temperature was provided for mouth

131 rinsing in between successive evaluation. Sample attributes (color, texture, taste, aroma, etc.  
132 were rated on a scoring scale of 1 to 9, where 1 = dislike extremely and 9 = like extremely  
133 Panelists made their responses on score sheets which were designed in line with the test  
134 procedures [35]. Mean scores for color, taste, texture, aroma and overall acceptability and degree  
135 of difference were analyzed by ANOVA. Post-hoc evaluation and separation of means was done  
136 using Duncan's test.

### 137 **2.11 Statistical Analysis**

138 The experimental results were expressed as mean  $\pm$  standard deviation (SD) of three replicates.  
139 Data obtained were statistically analyzed using one way Analysis of Variance (ANOVA), a tool  
140 in Statistical Packages for Social Scientists (SPSS 18.0). The level of significance was set at  $p <$   
141 0.05. Means were separated with Duncan's New Multiple Range Test (DNMRT).

## 142 **3.0 RESULT AND DISCUSSION**

### 143 **3.1 Pasting property of blends from wheat-bambara groundnut-moringa seed flour**

144 Table 2 shows the pasting profile of blends produced from wheat-bambara groundnut-Ground  
145 bean seed-moringa seed flours. The pasting temperature is an indication of the minimum  
146 temperature required to cook or gelatinize the flour [36]. There were no significant differences in  
147 pasting temperatures between the composite flour as well as wheat flour, but in general the  
148 pasting temperature in composite flour were higher than that of wheat flour. This may be due to  
149 the addition of ground bean in composite flours. A higher pasting temperature is an indication of  
150 higher water binding capacity, higher gelatinization tendency and lower swelling property of  
151 starch-based flour as a result of high degree of association between starch granules [37]. Peak  
152 viscosity which ranged between 114.17RVU (Relative visco-Analyzer unit) in WFF<sub>1</sub> (90%  
153 wheat: 10% composite flour) to 207.17 RVU in WFF<sub>3</sub> (70% wheat: 30% composite flour) is an

154 index of the ability of starch-based fruits to swell freely before their physical break down [38]  
155 The higher peak viscosity observed in the blends compared to 100% wheat could be attributed to  
156 the dilution of amylose contents in the composite blends. Zaidul *et al.* [39] and Blennow *et al.*  
157 [40] reported that high peak viscosity was associated with low amylose contents in flour. Peak  
158 viscosity is an indication of the thickening power of the starch, the higher the peak viscosity the  
159 higher the thickening power. The high peak viscosity values of the composite blends may be  
160 suitable for products requiring high gel strength and elasticity as reported [15]. The result for  
161 holding Strength revealed that sample WFF<sub>3</sub> ranked the highest (82.00) while sample WFF<sub>1</sub> had  
162 the least value (66.00 RVU). These values are relatively higher than the control sample value  
163 (64.33 RVU). It was observed that as the percentage of composite flour increased the holding  
164 strength increases. The Final Viscosity ranged between 111.86 RVU in WFF<sub>1</sub> and 123.44 RVU  
165 in WFF<sub>3</sub>. Final viscosity is commonly used to define the quality of particular starch based flour  
166 since it indicates the ability of the flour to form a viscous paste after cooking and cooling [41].  
167 The break down value was high in sample WFF<sub>1</sub> (43.00) while the least value was recorded in  
168 sample WFF<sub>3</sub> (36.00). It was observed that as the concentration of the composite flour increased  
169 the break down values decreased. High values of breakdown are associated with high peak  
170 viscosities, which in turn, are related to the degree of swelling of the starch granules during  
171 heating [42]. Lower setback viscosity indicates higher potential for retro-gradation in food  
172 products and gives an idea about retro-gradation tendency of starch [43]. Higher setback value is  
173 associated with cohesiveness. This study showed a setback viscosity range of 45.70 to 42.01  
174 RVU in WFF<sub>1</sub> and WFF<sub>3</sub> respectively. Arisa *et al.*, [44] reported a setback value of plantain  
175 flour treated with sodium metabisulphide to be 35.83 RVU which is slightly lower than the  
176 values reported in this study.



177 Table 2: Pasting property of Bread produced from wheat-bambara groundnut-moringa seed flour

Properties	WFF <sub>0</sub>	WFF <sub>1</sub>	WFF <sub>2</sub>	WFF <sub>3</sub>
Pasting temp. (°C)	68.50±0.71 <sup>b</sup>	68.77±0.51 <sup>b</sup>	69.50±0.23 <sup>b</sup>	70.0±0.17 <sup>a</sup>
Pasting time (min)	5.0±0.11 <sup>b</sup>	5.07±0.17 <sup>ab</sup>	5.07±0.15 <sup>a</sup>	5.14±0.21 <sup>a</sup>
Peak Viscosity (RVU)	101.17±0.83 <sup>d</sup>	114.17±0.51 <sup>c</sup>	119.17±0.99 <sup>a</sup>	207.17±1.27 <sup>b</sup>
Holding Strength (RVU)	64.33±1.12 <sup>d</sup>	66.00±0.83 <sup>c</sup>	77.0±1.07 <sup>b</sup>	82.0±0.92 <sup>a</sup>
Final Viscosity (RVU)	114.92±2.55 <sup>d</sup>	111.86±1.60 <sup>c</sup>	118.92±3.42 <sup>b</sup>	123.44±1.91 <sup>a</sup>
Break Down (RVU)	30.84±0.91 <sup>d</sup>	43.0±0.83 <sup>a</sup>	37.0±0.86 <sup>b</sup>	36.0±1.11 <sup>c</sup>
Set Back (RVU)	50.58±1.61 <sup>a</sup>	45.70±0.91 <sup>b</sup>	43.79±0.82 <sup>c</sup>	42.01±0.63 <sup>c</sup>

178 Results are mean of triplicates ± standard deviation. Values followed by different superscripts on

179 the same row are significantly different (p&lt; 0.05)

180 WFF<sub>0</sub>: 100% wheat flour (control), WFF<sub>1</sub>: 90% wheat: 10% (Bambara- groundnut-ground181 bean- moringa flour), WFF<sub>2</sub>: 80% wheat flour: 20% (Bambara- groundnut-ground bean- moringa182 flour), WFF<sub>3</sub>: 70% wheat: 30% (Bambara- groundnut-ground bean- moringa flour).183 **3.2 Physical composition of biscuit produced from wheat-bambara groundnut-moringa**184 **flour**

185 The result of physical characteristics of biscuits prepared from the flour blends are presented in

186 Table 3. There were significant differences in weight among the biscuit samples (P &lt; 0.05). The

187 highest weight was observed in the sample that contain wheat and 30% composite flour (WFF<sub>3</sub>)  
188 However, the weight of biscuit sample increases with increasing level of the composite flour  
189 This same trend was observed in composite flour made of soybean, maize, sweet potato and  
190 xanthan gum [45]. This could be of advantage to the biscuit industries as much weight gain in  
191 WFF<sub>3</sub> could lead to less packaging material thereby leading to much profit gained. The height  
192 ranged from 6.06 to 7.02cm. Sample WFF<sub>0</sub> (100% wheat) had the lowest value while sample  
193 WFF<sub>3</sub> (70% wheat, 30% composite flour) had the highest value. The height and diameter of the  
194 biscuit samples were also observed to increase gradually with increase in the level of composite  
195 flour, up to sample WFF<sub>3</sub>. Therefore, biscuits prepared from Bambara ground nut seed, moringa  
196 seed and ground bean seed flour compared favorably in height and diameter with the control  
197 (100% wheat flour). These observation is similar to the report of Kiin-Kabari and Giami [29] for  
198 cookies made from a blend of plantain and bambara protein concentrates. thickness of the  
199 biscuits prepared from the composite flour containing Bambara groundnut, moringa seed and  
200 ground bean seed flour varied significantly ( $P<0.05$ ) between the samples. The thickness of the  
201 biscuits was affected positively. Thickness of the biscuits showed gradual increase as the level of  
202 composite flour replacement from WFF<sub>0</sub> (100%) to WFF<sub>3</sub> (70%), except for sample WFF<sub>1</sub> which  
203 was lower than the control. Highest value (0.50 cm) was found in WFF<sub>3</sub> while the lowest value  
204 (0.40 cm) was found in WFF<sub>1</sub> (90% wheat flour: 10% composite flour). These findings were in  
205 agreement with what was observed by Bello *et al.*, [46] who found that the thickness of the  
206 biscuits was affected positively as there was an increase in the thickness of the biscuits by  
207 increasing levels of Mushroom flour supplementation. Thickness increased with increasing  
208 amount of crude fiber and crude protein. Spread factor is the ratio that depends on the values of  
209 the thickness and diameter of the biscuits. The spread factor of formulated biscuit decreased

210 from 86.26 - 80.00 with increase in composite flour content. The decrease in the spread factor of  
 211 the flour blends biscuits with an increase in the level of composited seed flour could be due to  
 212 the oil content of the moringa flour. A notable trend was observed, the biscuit spread factor  
 213 decreased with increase in protein content of the biscuits. The Increase in the protein content  
 214 observed competes for the available free water in the biscuits dough as a number of hydrophilic  
 215 sites are available, this could result to decrease in the spread  
 216 factor [47 - 48]

217 Table 3: Physical Attributes of biscuits produced from wheat-bambara groundnut-moringa seed  
 218 flour

219 Means ( $\pm$ SEM) with different superscripts in the same column are significantly different  
 220 ( $p < 0.05$ )

221 WFF<sub>0</sub>: 100% wheat flour (control), WFF<sub>1</sub>: 90% wheat: 10% (Bambara- groundnut-ground

Samples	Thickness (cm)	Diameter (cm)	Weight (g)	Height (cm)	Spread factor
WFF <sub>0</sub>	0.43 $\pm$ 0.01 <sup>a</sup>	3.27 $\pm$ 0.14 <sup>b</sup>	6.43 $\pm$ 0.14 <sup>c</sup>	6.06 $\pm$ 0.14 <sup>c</sup>	76.04 $\pm$ 0.52 <sup>d</sup>
WFF <sub>1</sub>	0.40 $\pm$ 0.07 <sup>a</sup>	3.45 $\pm$ 0.10 <sup>b</sup>	7.05 $\pm$ 0.30 <sup>c</sup>	6.34 $\pm$ 0.20 <sup>c</sup>	86.25 $\pm$ 0.91 <sup>a</sup>
WFF <sub>2</sub>	0.46 $\pm$ 0.09 <sup>a</sup>	3.89 $\pm$ 0.16 <sup>a</sup>	7.23 $\pm$ 0.34 <sup>b</sup>	6.72 $\pm$ 0.31 <sup>b</sup>	84.56 $\pm$ 1.27 <sup>b</sup>
WFF <sub>3</sub>	0.50 $\pm$ 0.03 <sup>a</sup>	4.00 $\pm$ 0.12 <sup>a</sup>	7.67 $\pm$ 0.24 <sup>a</sup>	7.02 $\pm$ 0.24 <sup>a</sup>	80.00 $\pm$ 1.50 <sup>c</sup>

222 bean- moringa flour), WFF<sub>2</sub>: 80% wheat flour: 20% (Bambara- groundnut-ground bean- moringa  
 223 flour), WFF<sub>3</sub>: 70% wheat: 30% (Bambara- groundnut-ground bean- moringa flour)

224 **3.3 Proximate and energy composition of biscuit produced from wheat-bambara**  
225 **groundnut-moringa seed flour**

226 The proximate and energy compositions of wheat-bambara groundnut-Ground bean seed-  
227 moringa seed flour are shown in Table 4. The moisture content of the wheat-bambara groundnut-  
228 Ground bean seed-moringa seed biscuit increased from 7.85% in WFF<sub>0</sub> - 8.45% in WFF<sub>3</sub>. These  
229 findings were lower than the results reported for sorghum-wheat composite flour biscuits [41].  
230 The low moisture content of the biscuit will require a unique packaging material to prevent  
231 reabsorption of moisture. The protein content of the biscuit increased from 12.50% - 16.19%  
232 with increase in bambara groundnut, Ground bean seed and moringa seed flour. Sample WFF<sub>0</sub>  
233 had no addition of bambara groundnut, Ground bean seed and moringa seed flour hence, had  
234 lowest protein content. Bambara nut is a rich source of protein. In comparison, these results were  
235 within the same range 12.61 – 15.03% for cookies from wheat, acha and pigeon pea flour blends  
236 reported [49]. The fat content ranged from 6.36% - 8.15% with increase in the blends in  
237 bambara groundnut-Ground bean seed-moringa seed flour which is a rich source of mineral. Fat  
238 could play a role in determining the shelf-life of foods. The low amount of fat present in the  
239 sample could help to prolong the shelf life of the product as the rate of rancidity which could  
240 lead to the production of off flavours and odours will be reduced drastically. The ash content  
241 increased from 1.26-2.01% with increase in the sample ratio. Ash content indicates the presence  
242 of mineral matter in food. Ash is a non-organic compound containing the mineral content of  
243 food. It aids in the metabolism of other compound such as protein fat and carbohydrate [50]. The  
244 crude fibre decreased from 2.83-1.84% with increase in flour blends. The fiber contents of all the  
245 cookies were within the Recommended Daily Allowance which should not exceed 5 g dietary  
246 fiber per 100 g dry matter [51]. The carbohydrate content of cookies ranged from 63.36 to

247 69.20%. The carbohydrate content of the sample is favourably compared with the [52]. This also  
 248 implies that the cookies could serve as a source of energy needed for body metabolism. The  
 249 energy content of the samples ranged from 384.04 kcal/100 g (WWF<sub>0</sub>) to 391.55 kcal/100 g in  
 250 WWF<sub>3</sub>. The energy value increased as the blends inclusion increase. This could be due to the low  
 251 fiber content present in the blends. The energy values of the biscuits are higher than 332.88  
 252 342.01 kcal for wheat cowpea based snack as reported [53].

253 Table 4: Proximate and energy composition of biscuit produced from wheat-bambara groundnut  
 254 moringa seed flours

Parameters	WWF <sub>0</sub>	WWF <sub>1</sub>	WWF <sub>2</sub>	WWF <sub>3</sub>	FAO, 2007
Moisture Content (%)	7.85±0.01 <sup>b</sup>	8.11±0.00 <sup>b</sup>	8.26±0.01 <sup>a</sup>	8.45±0.09 <sup>a</sup>	<10
Crude Protein (%)	12.50±0.02 <sup>c</sup>	14.40±0.13 <sup>b</sup>	15.84±0.04 <sup>b</sup>	16.19±0.23 <sup>a</sup>	>15
Crude Fat (%)	6.36±0.02 <sup>c</sup>	8.02±0.07 <sup>b</sup>	8.03±0.16 <sup>b</sup>	8.15±0.00 <sup>a</sup>	10-25
Crude Ash (%)	1.26±0.03 <sup>d</sup>	1.53±0.01 <sup>c</sup>	1.62±0.01 <sup>b</sup>	2.01±0.00 <sup>a</sup>	<3
Crude Fibre (%)	2.83±0.02 <sup>a</sup>	2.40±0.02 <sup>b</sup>	2.20±0.01 <sup>c</sup>	1.84±0.13 <sup>d</sup>	<5
Carbohydrate (g/100g)	69.20±0.05 <sup>a</sup>	65.54±0.11 <sup>b</sup>	64.05±0.30 <sup>c</sup>	63.36±0.20 <sup>d</sup>	64
Energy (K/cal)	384.04	391.34	391.83	391.55	344

255 Results are mean of triplicates ± standard deviation. Values followed by different superscripts on  
 256 the same row are significantly different (P< 0.05)

257 WFF<sub>0</sub>: 100% wheat flour (control), WFF<sub>1</sub>: 90% wheat: 10% (Bambara- groundnut-ground  
 258 bean- moringa flour), WFF<sub>2</sub>: 80% wheat flour: 20% (Bambara- groundnut-ground bean- moringa  
 259 flour), WFF<sub>3</sub>: 70% wheat: 30% (Bambara- groundnut-ground bean- moringa flour).

260 **3.4 Colour attribute of biscuit produced from wheat-bambara groundnut-moringa seed**  
 261 **flour**

262 The colour attribute is presented in Table 5. The biscuit sample WFF<sub>0</sub> had the highest value for  
 263 lightness 66.06 while WFF<sub>3</sub> had the least L\* value 51.85. A notable trend was observed, as the  
 264 blending ratio increased the lightness value decreased. Sample WFF<sub>2</sub> recorded higher a\* (10.77)  
 265 while sample WFF<sub>3</sub> (6.83) recorded the least degree of yellowness. The b\* value of the biscuits  
 266 range from 26.05 in WFF<sub>3</sub> to 17.92 WFF<sub>1</sub>. Baking process have influenced the colour of the  
 267 samples. Results obtained from this study is in agreement with Abano *et al.*, [54] who said that  
 268 the effect of heat on the carbohydrate during extrusion as a result of high temperature in the  
 269 extruder may have cause reaction between the amino acids and reducing sugars in the  
 270 complementary foods which may have accounted for the variation in the colour of the formulated  
 271 diets. Colour is an important quality parameter that influence market performance. Consumer  
 272 perceptions about some products are based on colour and many foods are associated with a  
 273 specific colour. Colour is by far one of the main quality criteria for consumers' acceptance of  
 274 food flour [55].

275 Table 5: Colour of biscuit produced from wheat-bambara groundnut-moringa seed flour

Sample	L*	a*	b*
WFF <sub>0</sub>	61.06 ± 4.95 <sup>ab</sup>	7.99±2.80 <sup>abc</sup>	22.00±6.70 <sup>a</sup>
WFF <sub>1</sub>	59.07±2.36 <sup>ab</sup>	6.83±1.09 <sup>bc</sup>	17.92±2.73 <sup>a</sup>

WFF <sub>2</sub>	57.84±8.09 <sup>ab</sup>	10.77±1.90 <sup>a</sup>	22.03±2.60 <sup>a</sup>
WFF <sub>3</sub>	51.85±3.17 <sup>b</sup>	9.64±0.95 <sup>ab</sup>	26.05±0.52 <sup>a</sup>

276

277 Results are mean of triplicates ± standard deviation. Values followed by different superscripts on  
 278 the same column are significantly different (P< 0.05)

279 WFF<sub>0</sub>: 100% wheat flour (control), WFF<sub>1</sub>: 90% wheat: 10% (Bambara- groundnut-ground  
 280 bean- moringa flour), WFF<sub>2</sub>: 80% wheat flour: 20% (Bambara- groundnut-ground bean- moringa  
 281 flour), WFF<sub>3</sub>: 70% wheat: 30% (Bambara- groundnut-ground bean- moringa flour).

282 **3.5 Mineral content of biscuit produced from wheat-bambara groundnut-moringa seed**  
 283 **flour**

284 The addition of Bambara- groundnut-ground bean- moringa flour is a good source of minerals as  
 285 presented in Table 6. The Calcium, Sodium, magnesium, Potassium and Phosphorous are the  
 286 predominant mineral elements present in the wheat-composite Biscuit. The mineral composition  
 287 obtained in this study shows that there was an increase in the phosphorous content of the biscuit  
 288 with increase in the level of flour blends. The Fe content of this study ranged from 3.61 in WFF<sub>0</sub>  
 289 – 2.83 mg/100 g in WFF<sub>3</sub> and it is lower than the recommended daily allowance (RDA) - 10 mg  
 290 of iron per day [56]. Iron is a major component of haemoglobin that carries oxygen to all parts of  
 291 the body. Iron also has a critical role within cells assisting in oxygen utilization, enzymatic  
 292 systems, especially for neural development, and overall cell function. Potassium was the most  
 293 abundant mineral in the biscuit followed by phosphorus and then calcium. The potassium content  
 294 of the samples ranged from 317.55 in WFF<sub>0</sub> - 395.25 mg/100 g in WFF<sub>3</sub> while phosphorus  
 295 ranged from 251.49 in WFF<sub>0</sub> - 338.95 mg/100 g In WFF<sub>3</sub> and calcium ranged from 76.95 in  
 296 WFF<sub>0</sub> - 98.20 mg/100 g in WFF<sub>3</sub>. These are in line with the report that the most abundant

297 mineral element in biscuit is potassium [57]. The increase in the phosphorous content of the  
 298 biscuit with increase in the level of Bambara- groundnut-ground bean- moringa flour addition is  
 299 an indication that Bambara- groundnut-ground bean- moringa is a good source of minerals. The  
 300 Sodium and potassium ratio is less than 1. This is good because it is required to maintain osmotic  
 301 balance of the body fluids, the pH of the body, to regulate muscle and nerve irritability, control  
 302 glucose absorption, and enhance normal retention of protein during growth [57]. Calcium content  
 303 ranged from 76.95 in WWF<sub>0</sub> to 98.20 mg/100g in WWF<sub>3</sub> and Mg ranged from 28.57 to 33.97  
 304 mg/100 g. The calcium content of the biscuits increased with increase in level of Bambara-  
 305 groundnut-ground bean- moringa flour addition, which means that the Bambara- groundnut-  
 306 ground bean- moringa has higher content of calcium than wheat. Without magnesium, calcium  
 307 may not be fully utilized, and under-absorption problems may occur resulting in arthritis  
 308 osteoporosis, menstrual cramps, and some premenstrual symptoms. Manganese, copper and zinc  
 309 are trace mineral elements that are essential for important biochemical functions and necessary  
 310 for maintaining health throughout life. While, Zinc (Zn) ranges from 0.60 – 0.65 mg/100 g  
 311 These values were comparable to what was reported [58].

312 **Table 6: Mineral content of biscuit produced from wheat-bambara groundnut-moringa**  
 313 **seed flour**

Parameters	WWF <sub>0</sub>	WWF <sub>1</sub>	WWF <sub>2</sub>	WWF <sub>3</sub>
Sodium (mg/100g)	41.45±0.35 <sup>c</sup>	44.25±0.35 <sup>b</sup>	44.75±0.07 <sup>b</sup>	49.15±0.49 <sup>a</sup>
Calcium (mg/100g)	76.95±1.91 <sup>d</sup>	86.30±0.28 <sup>c</sup>	90.40±1.27 <sup>b</sup>	98.20±0.14 <sup>a</sup>
Potassium (mg/100g)	317.55±1.63 <sup>b</sup>	320.10±0.00 <sup>b</sup>	382.15±1.91 <sup>b</sup>	395.25±0.21 <sup>a</sup>



Iron (mg/100g)	3.61±0.00 <sup>a</sup>	2.64±0.00 <sup>c</sup>	2.75±0.00 <sup>c</sup>	2.83±0.0c <sup>b</sup>
Magnesium (mg/100g)	28.57±0.01 <sup>d</sup>	32.66±0.18 <sup>c</sup>	41.00±0.18 <sup>a</sup>	33.97±0.21 <sup>b</sup>
Zinc (mg/100g)	0.60±0.00 <sup>d</sup>	0.62±0.01 <sup>c</sup>	0.63±0.01 <sup>b</sup>	0.65±0.00 <sup>a</sup>
Manganese (mg/100g)	0.35±0.01 <sup>d</sup>	0.35±0.00 <sup>c</sup>	0.37±0.00 <sup>b</sup>	0.48±0.00 <sup>a</sup>
Phosphorus (mg/100g)	251.49±0.99 <sup>d</sup>	262.45±1.02 <sup>c</sup>	294.87±0.38 <sup>b</sup>	338.95±1.75 <sup>a</sup>
Iodine (mg/100g)	0.38±0.06 <sup>a</sup>	0.30±0.01 <sup>a</sup>	0.35±0.07 <sup>a</sup>	0.36±0.12 <sup>a</sup>
Na/K	0.13	0.13	0.1	0.12

314 Results are mean of triplicates ± standard deviation. Values followed by different superscripts of  
 315 the same row are significantly different (P< 0.05)

316 WFF<sub>0</sub>: 100% wheat flour (control), WFF<sub>1</sub>: 90% wheat: 10% (Bambara- groundnut-ground  
 317 bean- moringa flour), WFF<sub>2</sub>: 80% wheat flour: 20% (Bambara- groundnut-ground bean- moringa  
 318 flour), WFF<sub>3</sub>: 70% wheat: 30% (Bambara- groundnut-ground bean- moringa flour).

### 319 **3.6 Sensory attribute of biscuit produced from wheat-bambara groundnut-moringa** 320 **seed flour**

321 The effect of added bambara groundnut-Ground bean seed-moringa seed flour on the quality of  
 322 biscuit is summarized on Table 7. The addition of bambara groundnut-Ground bean seed and  
 323 moringa seed flour decreased the mean score of the colour from 7.00 in WFF<sub>0</sub> - 5.20 in WFF<sub>3</sub> as  
 324 the concentration (0-30%) of the blends increase. This could be due to the natural inherent  
 325 pigment of the bambara groundnut-Ground bean seed and moringa seed flour added. It could  
 326 also be due to enzymatic browning, which might have given an impression of the products been  
 327 over baked to the panellist hence the less liking effect. These results are comparable to the result  
 328 of Mouni *et al.*, [59] who also reported a decrease from 8.30 – 5.27 in the mean colour as the

329 ratio of Jujubes increased. The addition of bambara groundnut-Ground bean seed-moringa seed  
 330 flour decreased the mean score of the taste from 7.53 - 4.40 as the percentage (0-30%) of the  
 331 blends increased. This could be due to increase in the sugar, fat and some other compounds in  
 332 the bambara groundnut-Ground bean seed-moringa seed flour. The addition of bambara  
 333 groundnut-Ground bean seed-moringa seed flour decreased the mean score of the texture from  
 334 6.60-5.47 as the percentage (0-30%) of the added bambara groundnut-Ground bean seed-  
 335 moringa seed flour increased. This could be due to the increase in the sugar content and decrease  
 336 in the carbohydrate content of the added bambara groundnut-Ground bean seed-moringa seed  
 337 flour. The addition of the flour blends decreased the mean score of the aroma from 6.53-4.53 as  
 338 the percentage (0-30%) of the blends increased. The addition of bambara groundnut-Ground  
 339 bean seed-moringa seed flour decreased the mean score of the general acceptability from 7.20-  
 340 4.87 as the concentration (0-30%) of the blends increased. Similar trend was observed by Akoja  
 341 and Coker [60] for biscuits by increasing the concentration of okro powder in the formulation.

342 Table 7: Sensory attribute of biscuit produced from wheat-bambara groundnut-moringa seed  
 343 flour

Parameters	WFF <sub>0</sub>	WFF <sub>1</sub>	WFF <sub>2</sub>	WFF <sub>3</sub>
Colour	7.00±1.85 <sup>a</sup>	6.00±1.07 <sup>b</sup>	5.60±1.05 <sup>b</sup>	5.20±1.32 <sup>b</sup>
Taste	7.53±1.19 <sup>a</sup>	6.40±0.83 <sup>b</sup>	6.00±1.09 <sup>c</sup>	4.40±1.35 <sup>d</sup>
Aroma	6.53±1.19 <sup>a</sup>	6.13±1.60 <sup>a</sup>	4.80±1.21 <sup>b</sup>	4.53±1.60 <sup>c</sup>
Texture	6.60±1.24 <sup>a</sup>	6.13±1.41 <sup>b</sup>	5.93±1.22 <sup>c</sup>	5.47±1.19 <sup>c</sup>
Overall acceptability	7.20±0.86 <sup>a</sup>	6.80±1.55 <sup>b</sup>	6.20±1.01 <sup>c</sup>	4.87±1.06 <sup>d</sup>

344

345 Results are mean of triplicates  $\pm$  standard deviation. Values followed by different superscripts on  
346 the same row are significantly different ( $P < 0.05$ )  
347 WFF<sub>0</sub>: 100% wheat flour (control), WFF<sub>1</sub>: 90% wheat: 10% (Bambara- groundnut-ground  
348 bean- moringa flour), WFF<sub>2</sub>: 80% wheat flour: 20% (Bambara- groundnut-ground bean- moringa  
349 flour), WFF<sub>3</sub>: 70% wheat: 30% (Bambara- groundnut-ground bean- moringa flour).

### 350 **Conclusion**

351 The inclusion of the blends of Bambara groundnut, Ground bean seed and Moringa seed flours to  
352 wheat flour in the production of biscuits enhanced the protein, energy and mineral contents of the  
353 biscuits. For the pasting properties a notable trend was observed that as the concentration of the  
354 flour blend increased the break down values decreased. Therefore, sample with 70% wheat: 30%  
355 blends (WFF<sub>3</sub>) was the best formulation which guaranteed enough protein, energy value, Ash  
356 fat, colour and minerals.

### 357 **COMPETING INTERESTS**

358 Authors have declared that no competing interest exist

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